[0061] FIG. **49** illustrates a reflector layer in the example ECB LCD display using LTPS according to embodiments of the invention.

[0062] FIG. **50** illustrates an ITO layer in the example ECB LCD display using LTPS according to embodiments of the invention.

[0063] FIG. **51** illustrates a completed pixel in the example ECB LCD display using LTPS according to embodiments of the invention.

[0064] FIG. **52** illustrates a side view of a pixel in the example ECB LCD display using LTPS according to embodiments of the invention.

[0065] FIG. **53** illustrates a calculation of the storage capacitance of a pixel in the example ECB LCD display using LTPS according to embodiments of the invention.

[0066] FIG. **54** illustrates an aperture ratio estimation of pixels in the example ECB LCD display using LTPS according to embodiments of the invention.

[0067] FIG. **55** illustrates an example modification in the example ECB LCD display using LTPS according to embodiments of the invention.

[0068] FIG. **56** illustrates a portion of a touch screen that includes an example grounded separator region according to embodiments of the invention.

[0069] FIG. **57** is a side view of the example touch screen of FIG. **56**, which illustrates an example high R shield according to embodiments of the invention.

[0070] FIG. **58** illustrates a side view of a portion of an example touch screen including black mask lines of a black mask and metal lines under the black mask lines according to embodiments of the invention.

[0071] FIG. **59** illustrates an example black mask layout according to embodiments of the invention.

[0072] FIG. **60** illustrates an example IPS-based touch-sensing display in which the pixel regions serve multiple functions.

[0073] FIG. **61** illustrates an example computing system that can include one or more of the example embodiments of the invention.

[0074] FIG. **62***a* illustrates an example mobile telephone that can include a touch screen including pixels with dual-function capacitive elements according to embodiments of the invention.

[0075] FIG. **62***b* illustrates an example digital media player that can include a touch screen including pixels with dual-function capacitive elements according to embodiments of the invention.

[0076] FIG. **62***c* illustrates an example personal computer that can include a touch screen including pixels with dual-function capacitive elements according to embodiments of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0077] In the following description of preferred embodiments, reference is made to the accompanying drawings which form a part hereof, and in which it is shown by way of illustration specific embodiments in which the invention can be practiced. It is to be understood that other embodiments can be used and structural changes can be made without departing from the scope of the embodiments of this invention.

[0078] This relates to displays including pixels with dual-function capacitive elements. Specifically, these dual-function capacitive elements form part of the display system that generates an image on the display, and also form part of a touch sensing system that senses touch events on or near the display. The capacitive elements can be, for example, capacitors in pixels of an LCD display that are configured to operate individually, each as a pixel storage capacitor, or electrode, of a pixel in the display system, and are also configured to operate collectively as elements of the touch sensing system. In this way, for example, a display with integrated touch sensing capability may be manufactured using fewer parts and/or processing steps, and the display itself may be thinner and brighter.

[0079] FIG. **1** is a partial circuit diagram of an example LCD display **100** including a plurality of LCD pixels according to embodiments of the present invention. The pixels of panel **100** are configured such that they are capable of dual-functionality as both LCD pixels and touch sensor elements. That is, the pixels include capacitive elements or electrodes, that can operate as part of the LCD display circuitry of the pixels and that can also operate as elements of touch sensing circuitry. In this way, panel **100** can operate as an LCD display with integrated touch sensing capability. FIG. **1** shows details of pixels **101**, **102**, **103**, and **104** of display **100**.

[0080] Pixel **102** includes a thin film transistor (TFT) **155** with a gate **155***a*, a source **155***b*, and a drain **155***c*. Pixel **102** also includes a storage capacitor, Cst **157**, with an upper electrode **157***a* and a lower electrode **157***b*, a liquid crystal capacitor, Clc **159**, with a pixel electrode **159***a* and a common electrode **159***b*, and a color filter voltage source, Vcf **161**. If a pixel is an in-plane-switching (IPS) device, Vcf can be, for example, a fringe field electrode connected to a common voltage line in parallel with Cst **157**. If a pixel does not utilize IPS, Vcf **151** can be, for example, an ITO layer on the color filter glass. Pixel **102** also includes a portion **117***a* of a data line for green (G) color data, Gdata line **117**, and a portion **113***b* of a gate line **113**. Gate **155***a* is connected to gate line portion **113***b*, and source **155***b* is connected to Gdata line portion **117***a*. Upper electrode **157***a* of Cst **157** is connected to drain **155***c* of TFT **155**, and lower electrode **157***b* of Cst **157** is connected to a portion **121***b* of a common voltage line that runs in the x-direction, xVcom **121**. Pixel electrode **159***a* of Clc **159** is connected to drain **155***c* of TFT **155**, and common electrode **159***b* of Clc **159** is connected to Vcf **151**.

[0081] The circuit diagram of pixel **103** is identical to that of pixel **102**. However, color data line **119** running through pixel **103** carries blue (B) color data. Pixels **102** and **103** can be, for example, conventional LCD pixels.

[0082] Similar to pixels **102** and **103**, pixel **101** includes a thin film transistor (TFT) **105** with a gate **105***a*, a source **105***b*, and a drain **105***c*. Pixel **101** also includes a storage capacitor, Cst **107**, with an upper electrode **107***a* and a lower electrode **107***b*, a liquid crystal capacitor, Clc **109**, with a pixel electrode **109***a* and a common electrode **109***b*, and a color filter voltage source, Vcf **111**. Pixel **101** also includes a portion **115***a* of a data line for red (R) color data, Rdata line **115**, and a portion **113***a* of gate line **113**. Gate **105***a* is connected to gate line portion **113***a*, and source **105***b* is connected to Rdata line portion **115***a*. Upper electrode **107***a* of Cst **107** is connected to drain **105***c* of TFT **105**, and lower electrode **107***b* of Cst **107** is connected to a portion **121***a* of xVcom **121**. Pixel electrode **109***a* of Clc **109** is connected to drain **105***c* of TFT **105**, and common electrode **109***b* of Clc **109** is connected to Vcf **111**.

[0083] Unlike pixels **102** and **103**, pixel **101** also includes a portion **123***a* of a common voltage line running in the y-di-